Current status of the California Central Valley Groundwater-Surface Water Simulation Model (C2VSIM)

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Acknowledgements

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CH_2MHill

Matt Tonkin
SS Papadopulos & Associates

* currently with MBK Engineers

Outline

- Central Valley Development
- Overview of the C2VSIM model
- Geology of Central Valley Aquifer
- Model Calibration and Performance
- Water budgets
- Scenarios
  - In-Lieu Conjunctive Use Scenario
  - Climate Change Scenarios
- Summary

C2VSIM Model Grid

Finite Element Grid

- 3 layers
- 1393 nodes
- 1392 elements

Surface Water System

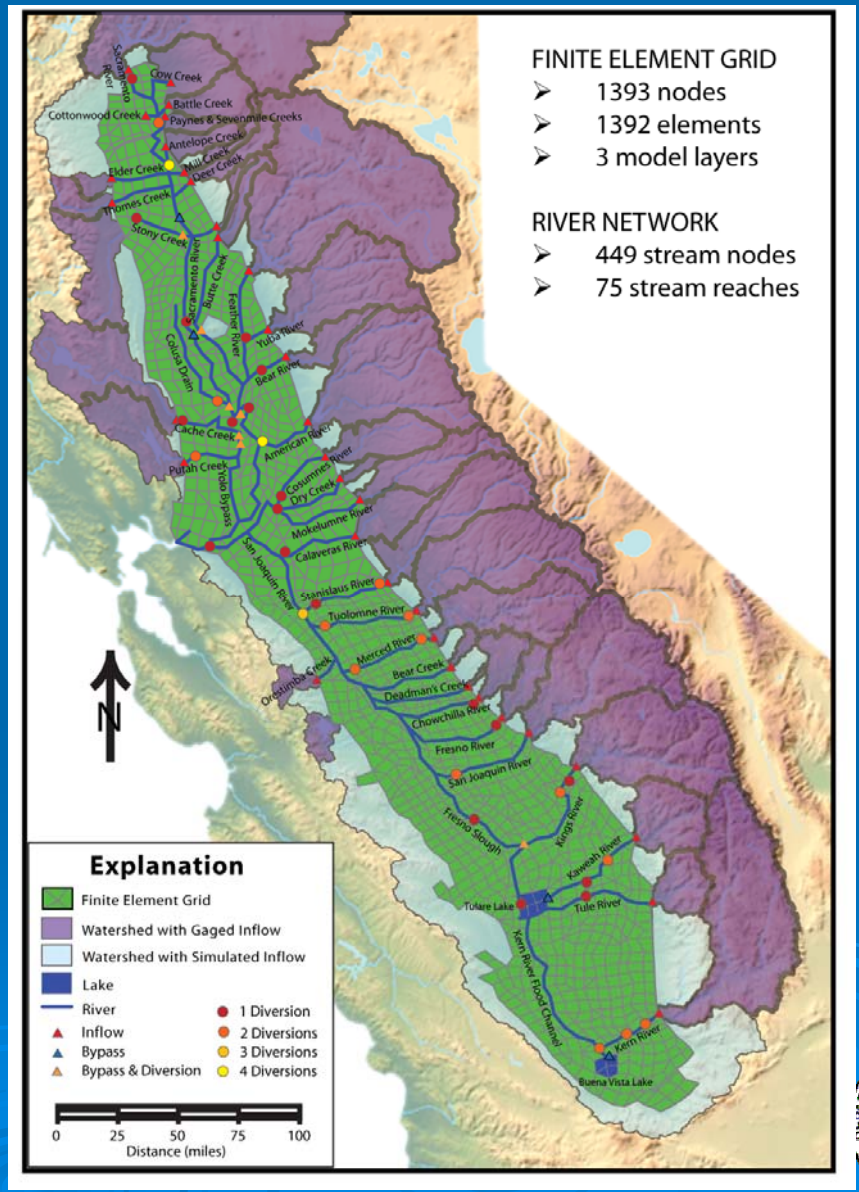
- 75 river reaches
- 2 lakes
- 97 surface water diversion points
- 6 bypasses

Land Use Process

- 21 subregions
- 4 Land Use Types
  - Agriculture
  - Urban
  - Native
  - Riparian

Simulation periods

- 10/1921-9/2003
- 10/1972-9/2003 (<4 min)



Groundwater Model Components

Component	Source
Parameters	calibration: WY 1973-2003
Initial conditions	water-level observations, 10/1921 or 10/1972
Boundary conditions	- Precipitation & evapotranspiration - Surface water inflows & diversions
Recharge & Pumping calc	- Land use & crop acreages - Crop coefficients - Soil type, SCS curve number - Pump locations (well database)

C2VSIM Subregions

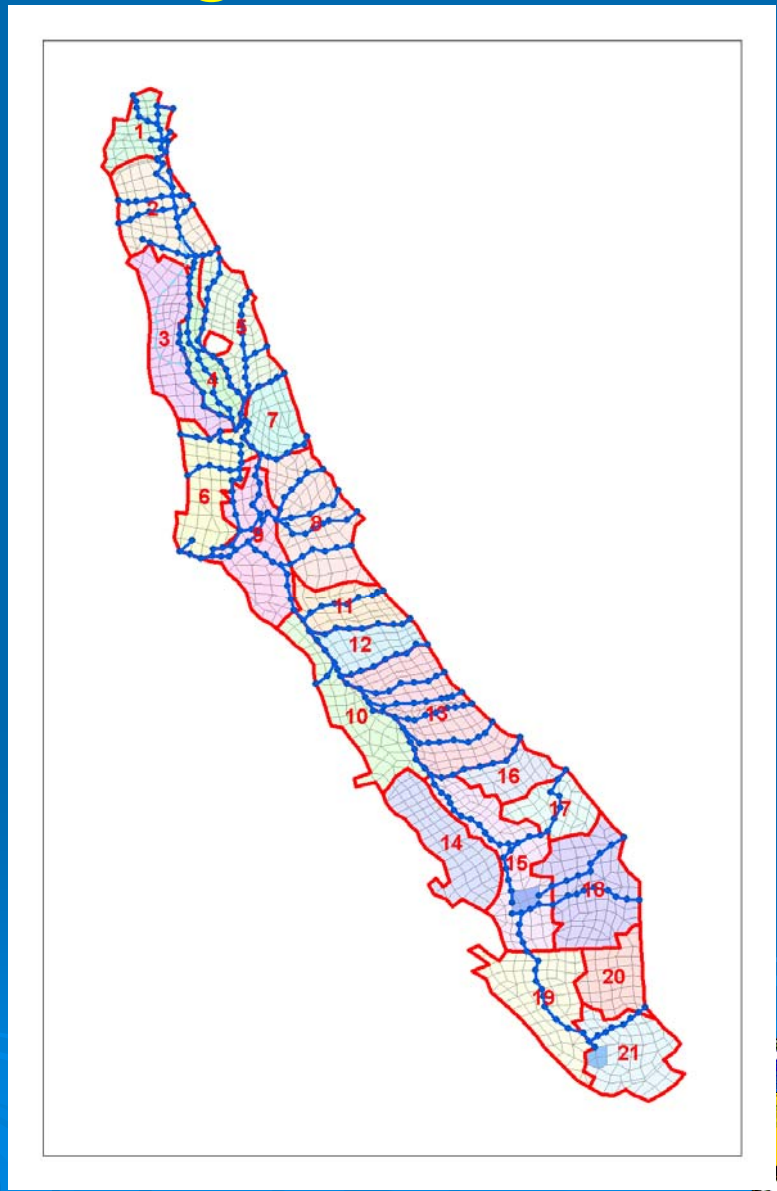
Water Budget Calculations

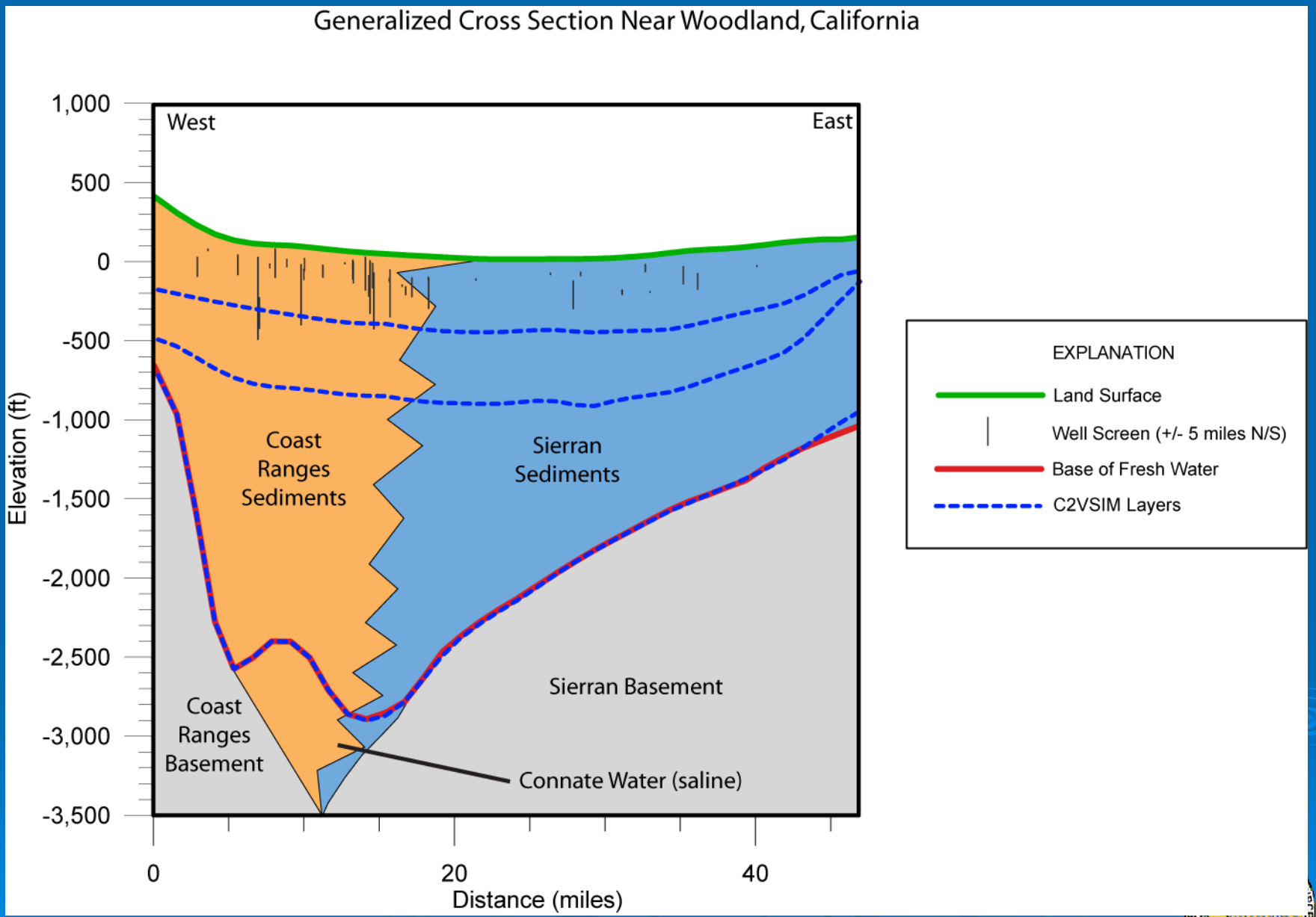
- Land use by element
- Aggregate to subregion

By land use in subregion:

- Calculate water demands
- Apply soil moisture
- Apply surface water diversions
- Apply/estimate groundwater pumping
- Calculate soil moisture, recharge, return flows

Allocate to elements by land use areas




Generalized Cross Section Near Woodland, California
West
East
1,000
500
0
-500
-1,000
-1,500
-2,000
-2,500
-3,000
-3,500
Elevation (ft)
Coast Ranges Sediments
Sierran Sediments
Sierran Basement
Coast Ranges Basement
Connate Water (saline)
0
20
40
Distance (miles)
EXPLANATION
Land Surface
Well Screen (+/- 5 miles N/S)
Base of Fresh Water
C2VSIM Layers

C2VSIM Initial Calibration

Pilot Points

- 139 in layers 1 and 2 (K_h, K_v, S_y, S_s)
- 39 in layer 3 (K_h, K_v, S_s)
- 19 for Corcoran Clay (K_v)

Calibration Observations

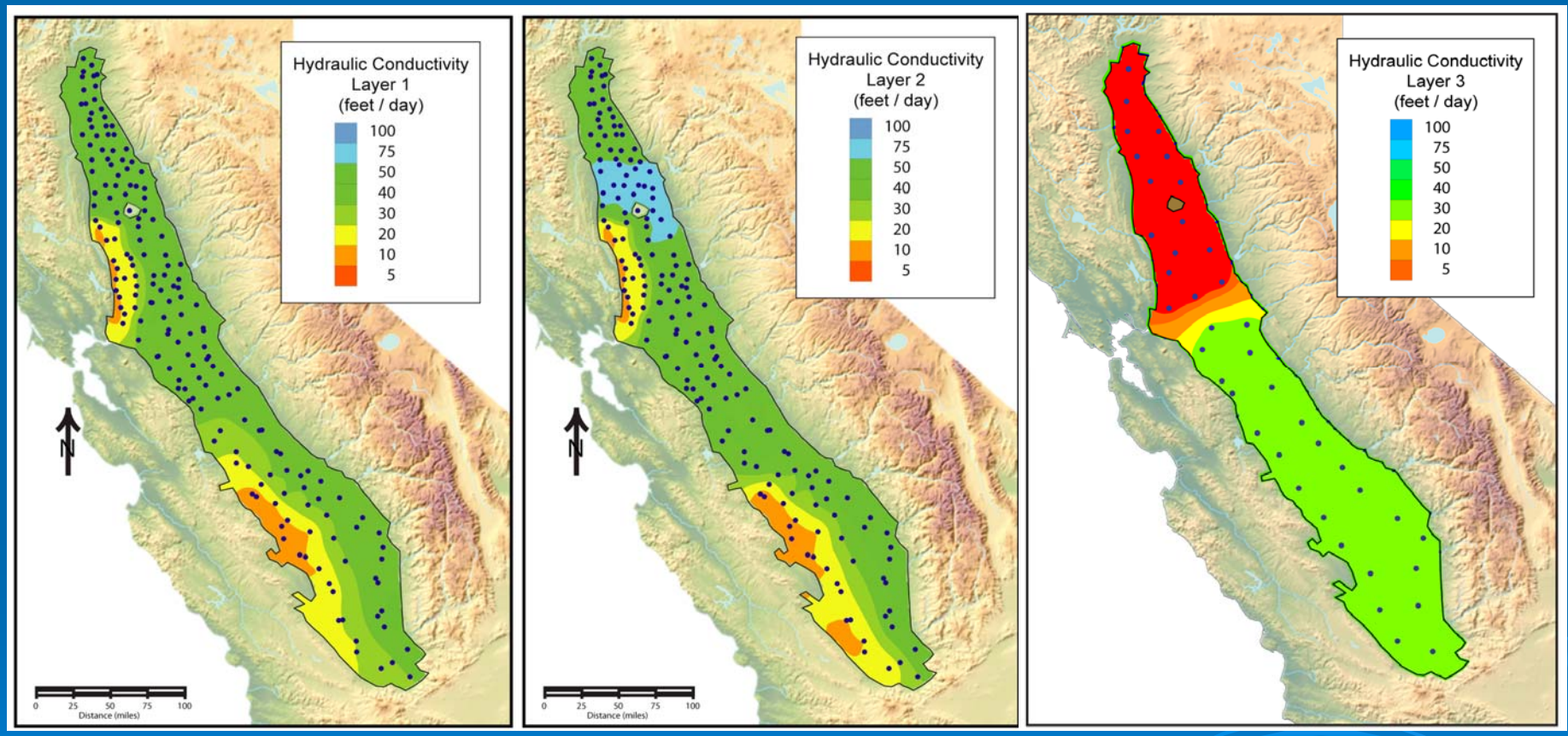
Sites	per site	total
221 groundwater head	52	10,503
9 vertical head gradient	52	1,976
9 river flow	52*	3,276
34 stream-groundwater flow reaches	1**	34

Calibration Period Water Years 1975-99 (IC 10/1972)

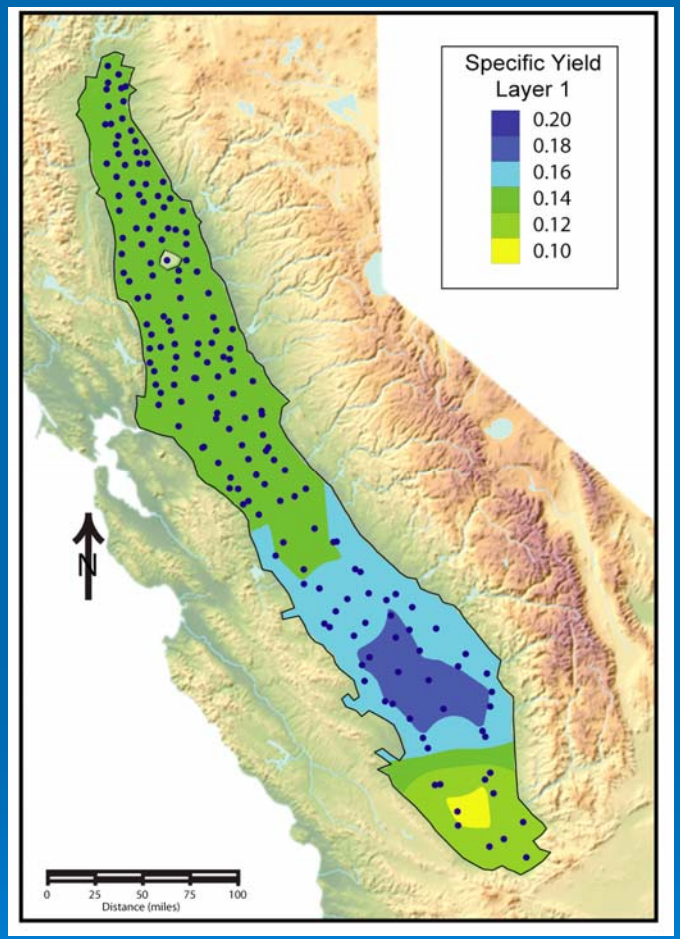
Validation Period Water Years 1975-99 (IC 10/1921)

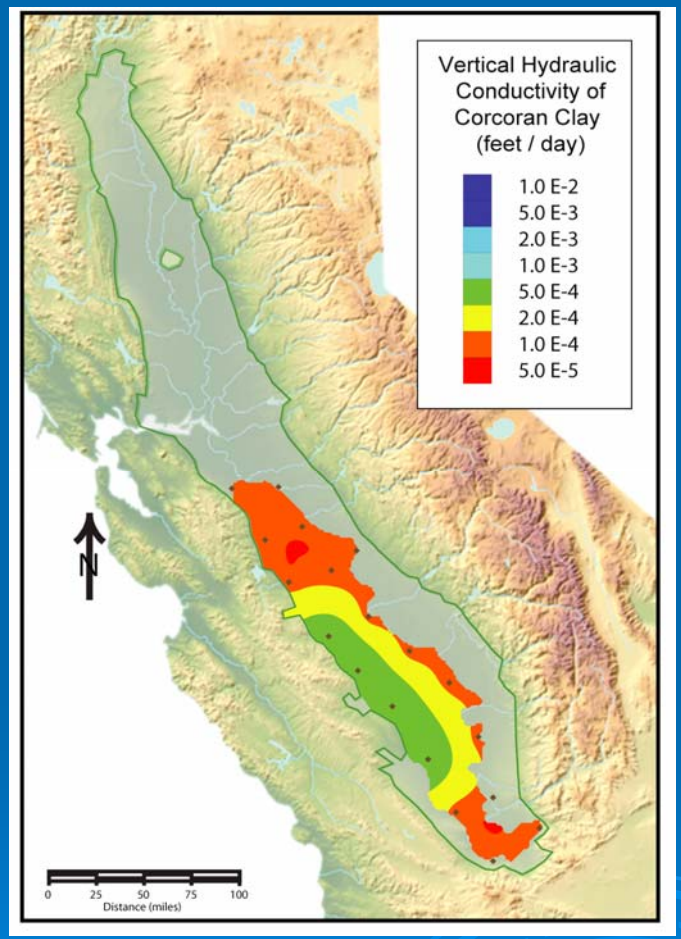
* For 8 of 9, ** monthly average rate

Hydraulic Conductivity

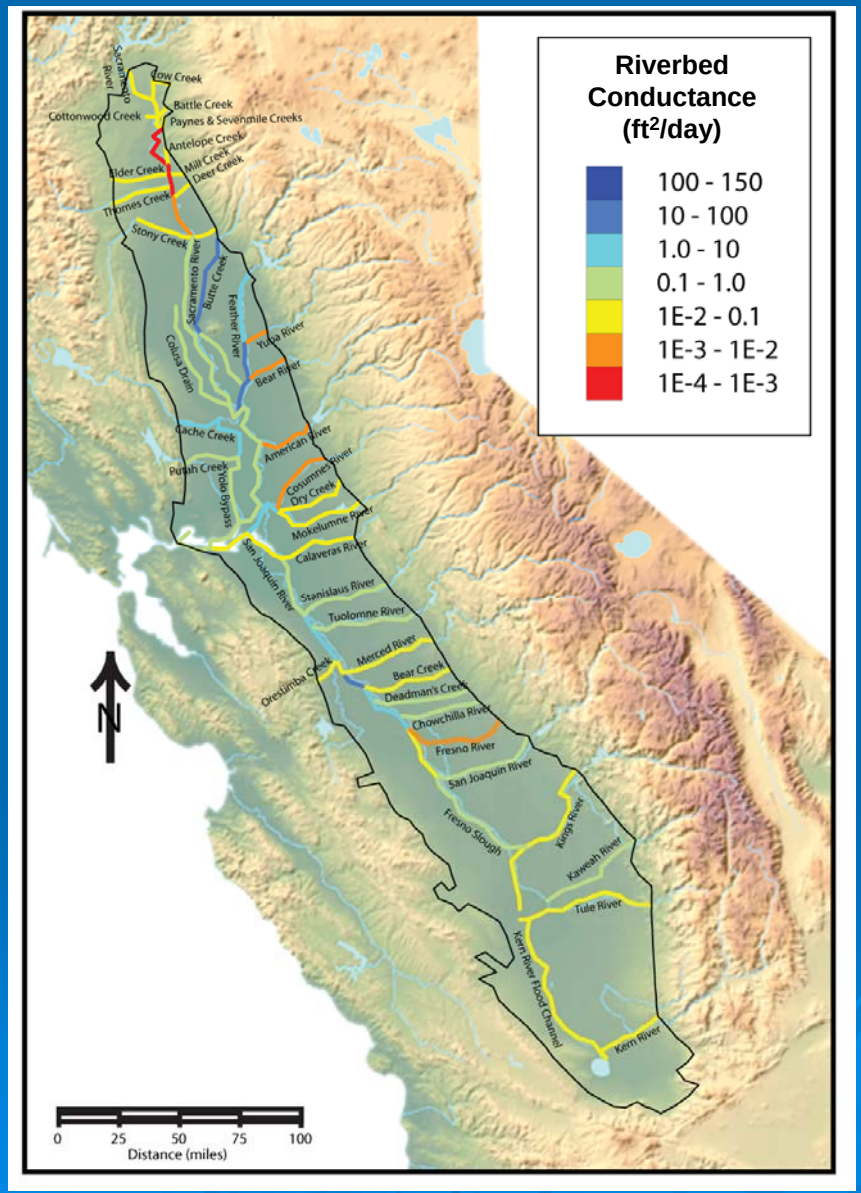


Specific Yield & Kv of Corcoran Clay





Streambed Conductance



Model Improvements 2006-2008

- IWFM v2.3 to v3.01
- Distributed monthly precipitation using PRISM
- Groundwater pumping distribution matches well log database
- Added new small watersheds around valley rim
- Corrected errors in diversions and surface water imports
- Modified Buena Vista Lake and Tulare Lake
- Modified representations of the lower Kern River, Kings River, Kaweah River, Tule River, Sacramento-San Joaquin Delta

Current C2VSIM Calibration

Initiated September 2008, Complete February 2009

Improved IWFM-PEST utilities

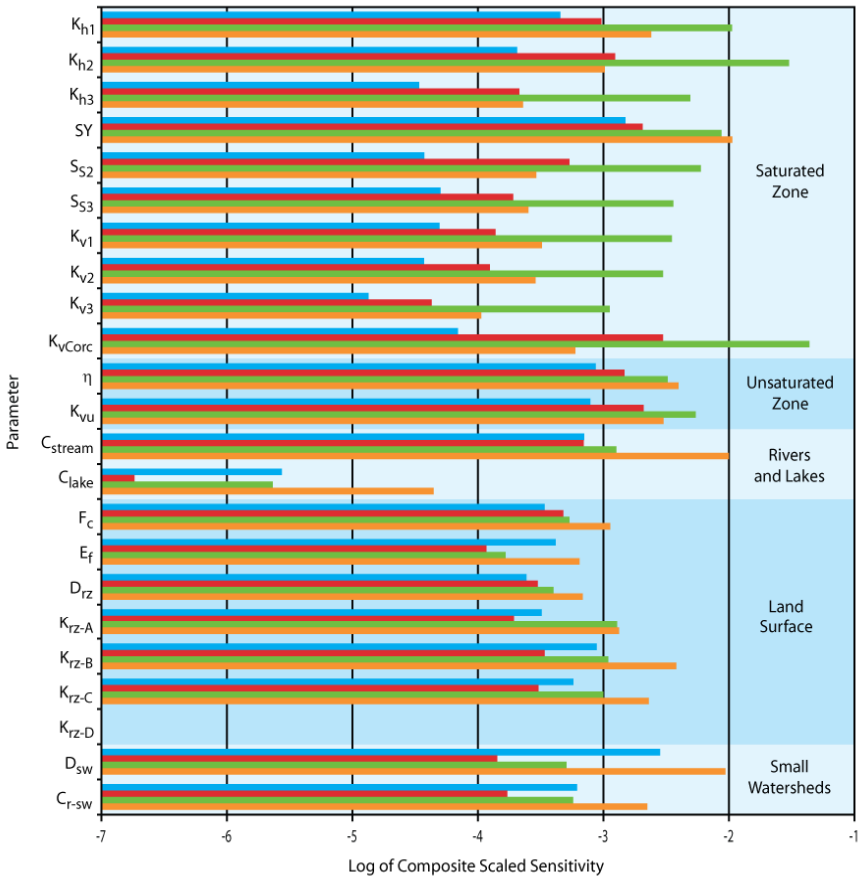
Expand number of pilot points

Increase calibration data set (observations)

especially vertical head gradients, stream-groundwater flow

Compare output to other DWR water budget data

Parameter Sensitivities vs. Observation Types



Parameter Key

K_{h1}	Horizontal K, layer 1	C_{stream}	Streambed conductance
K_{h2}	Horizontal K, layer 2	C_{lake}	Lake bottom conductance
K_{h3}	Horizontal K, layer 3	F_c	Field capacity of soil
SY	Specific yield	E_f	Total porosity of soil
S_{s2}	Specific storage, layer 2	D_{rz}	Root-zone depth
S_{s3}	Specific storage, layer 3	K_{rz-A}	Root-zone Kv, soil group A
K_{v1}	Vertical K, layer 1	K_{rz-B}	Root-zone Kv, soil group B
K_{v2}	Vertical K, layer 2	K_{rz-C}	Root-zone Kv, soil group C
K_{v3}	Vertical K, layer 3	K_{rz-D}	Root-zone Kv, soil group D
K_{vCorc}	Vertical K, Corcoran Clay	D_{sw}	Root-zone depth, small watersheds
η	Effective porosity, unsat. Zone	C_{r-sw}	Recession coefficients, small watersheds
K_{vu}	Vertical K, unsat. Zone		

Simulated Water Budget Components

Average Annual Rates for Water Years 1975-2003

	Storage	Stream Leakage	Subsidence	Pumpage	Recharge	Interbasin Flows
Sacramento Valley	200,174	-350,859	51	-2,089,333	2,225,060	14,908
Delta	-82,464	-30,188	-105	-204,022	430,915	-114,136
Eastside Streams	139,029	109,888	50	-771,925	308,327	214,631
San Joaquin Basin	150,969	-499,100	798	-1,414,172	1,935,691	-174,196
Tulare Basin	-2,109,300	-485,561	-9,533	-3,807,986	6,350,697	58,794
Model Area	-1,701,592	-1,255,821	-8,739	-8,287,438	11,250,690	0

Acre-Feet per Year

Simulated Water Budget Components

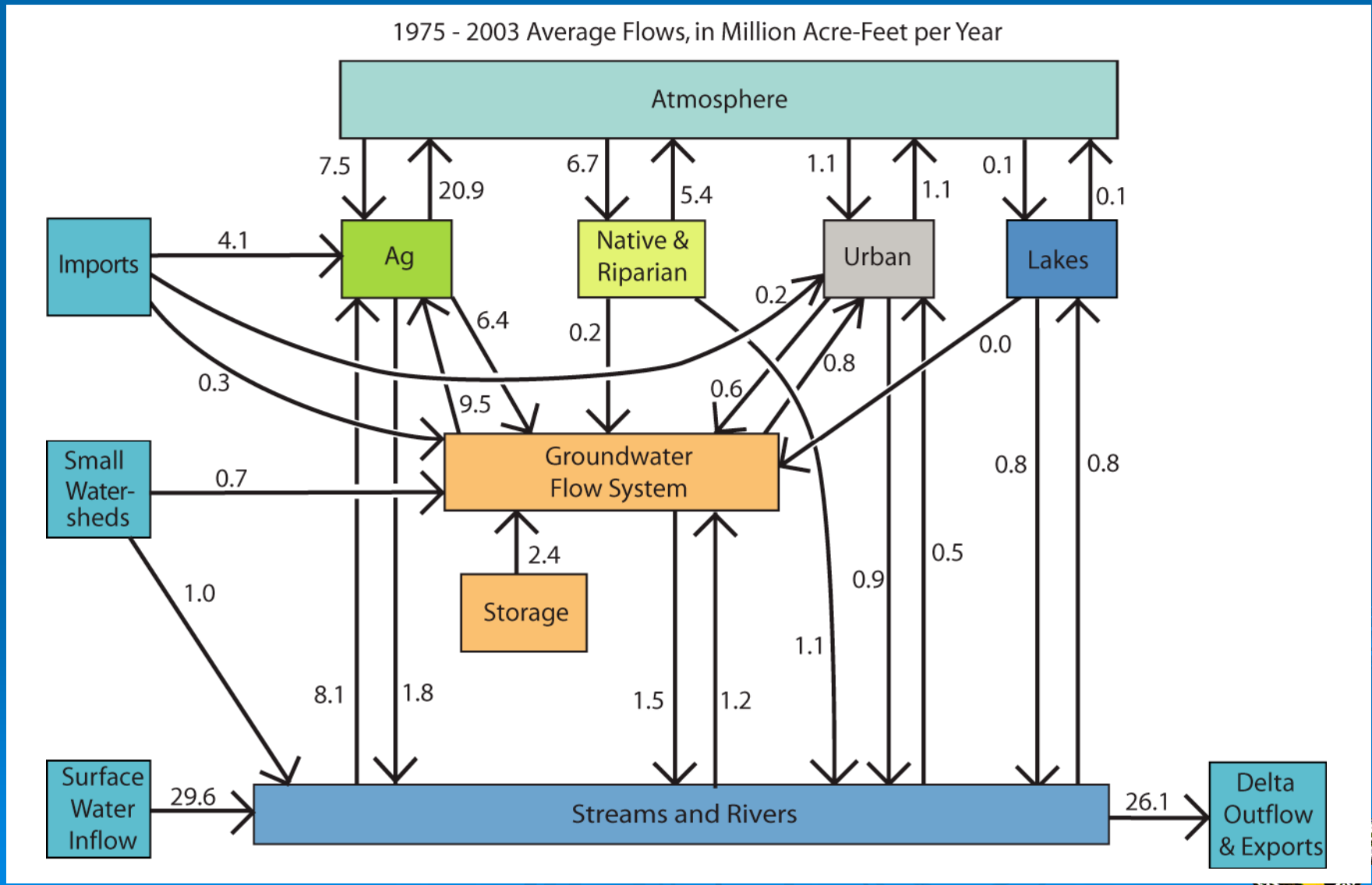
Average Annual Rates for Water Years 1975-2003

	Surface Water Inflows*	Surface Water Outflows*	Precipitation	Actual Evapo-transpiration
Sacramento Valley	19,955,538	17,759,801	6,849,346	8,472,276
Delta	31,005,209	25,564,486	926,265	1,533,207
Eastside Streams	1,307,325	1,443,871	1,405,900	1,683,961
San Joaquin Basin	5,820,154	4,535,437	2,521,049	5,544,759
Tulare Basin	3,220,309	1,179,001	3,584,871	10,596,423
Model Area	30,923,480	26,783,332	15,287,431	27,830,625

* Surface water inflows and outflows do not add up across hydrologic regions

Acre-Feet per Year

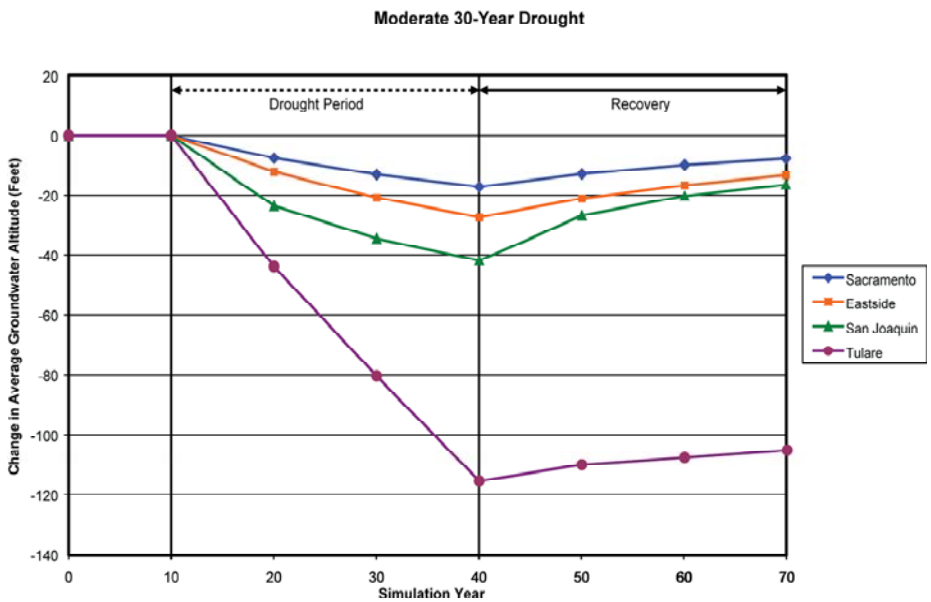
Water Budget

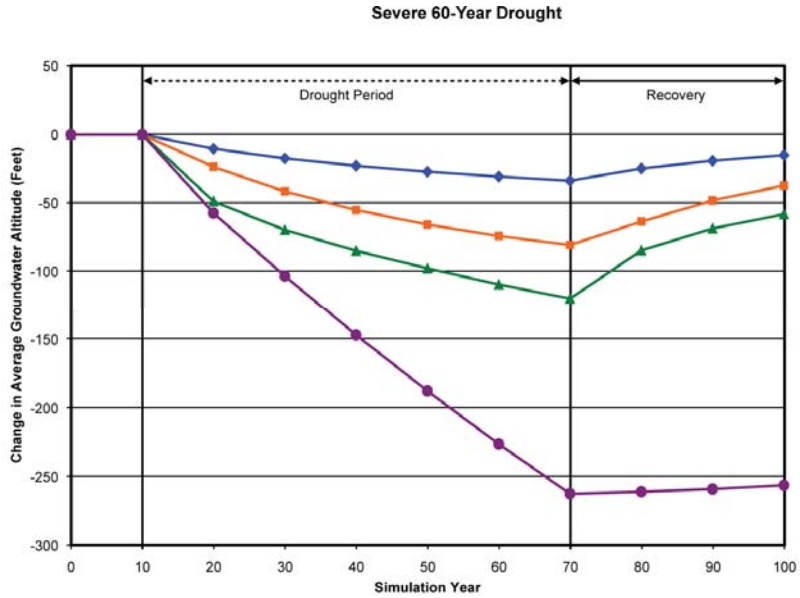


C2VSIM Applications

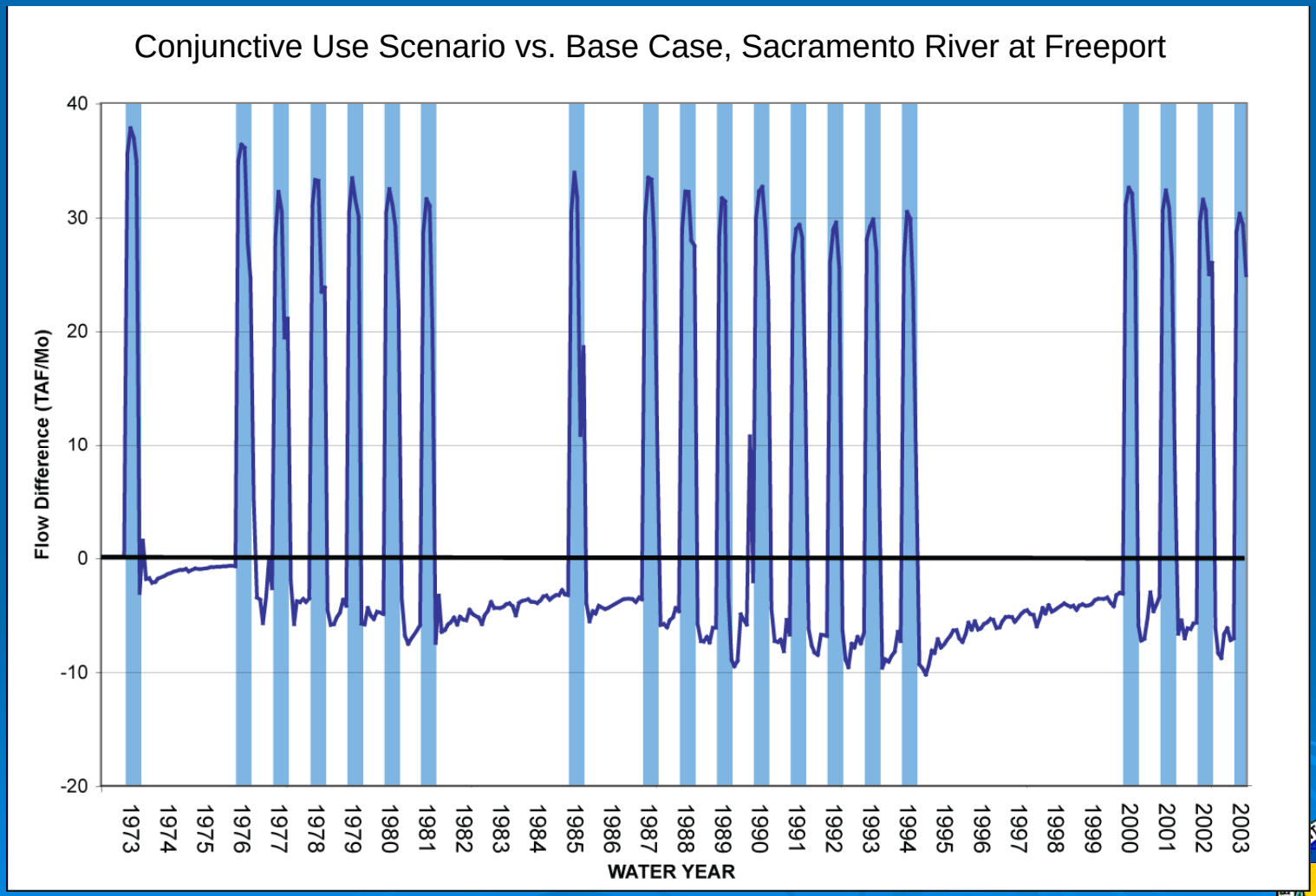
- Groundwater component of CALSIM-III
- Response of Central Valley groundwater systems to prolonged drought (with Norm Miller, Larry Dale and Sebastian Vicuna of LBL/UCB)
- Impacts of conjunctive use groundwater extraction on stream-groundwater interactions in the Sacramento Valley

C2VSIM Applications
Groundwater Response to Extended Drought





C2VSIM Applications
Groundwater Impacts on River Flow



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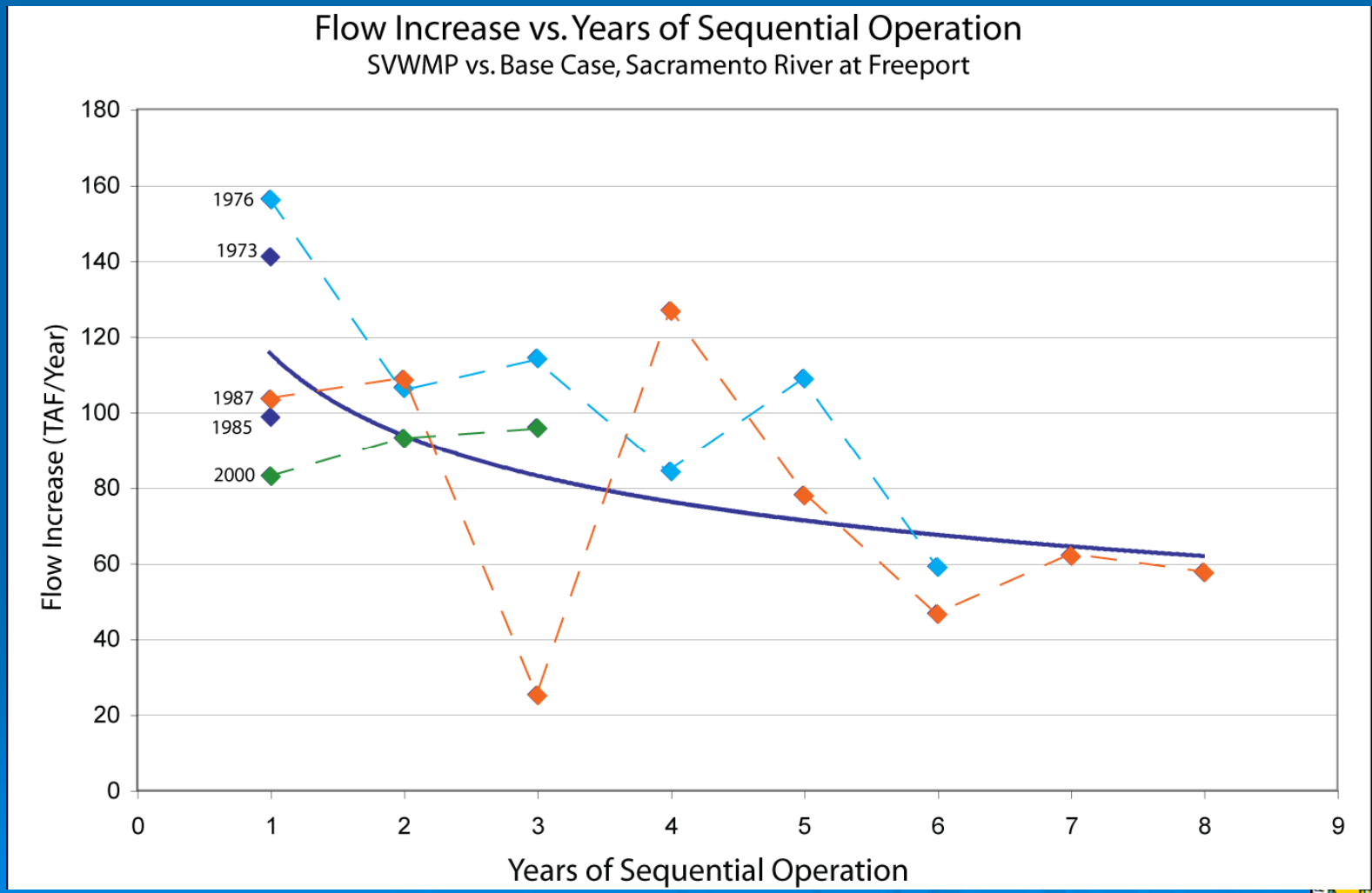

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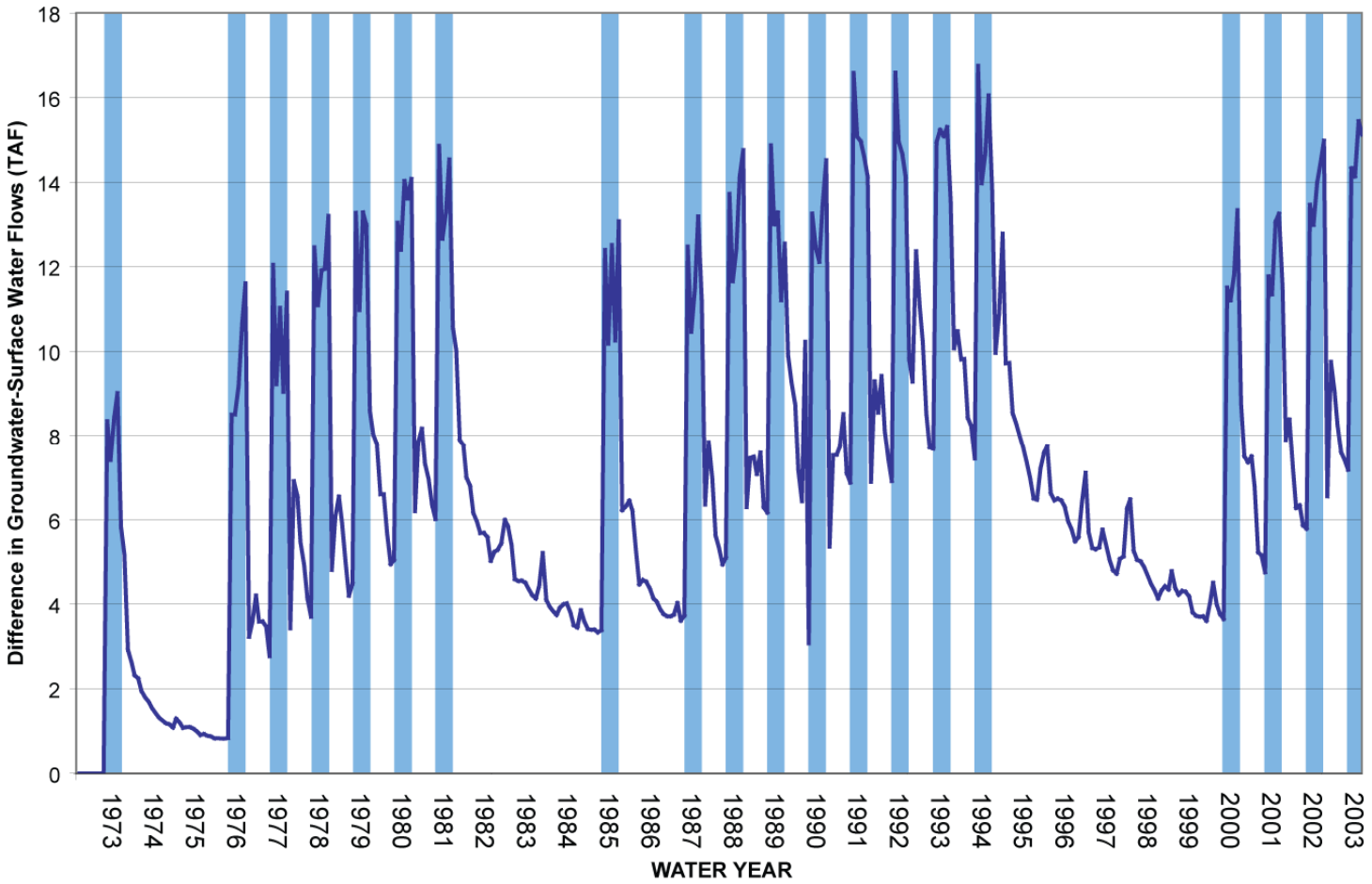
Groundwater Impacts on River Flow



Summary

C2VSIM model performs well

- Regional parameters provide good results
- Lots of information – areal recharge, storage, GW-SW
- Groundwater pumping estimates look reasonable
- Subregional ‘virtual farms’ limit spatial resolution
- Useful for basin-wide assessments of groundwater response and impacts

Further model calibration

- Improved IWFM-PEST tools
- Increase spatial variability of parameters
- Increase observation data set
- Planned release in spring 2009

Future Work

Spatial refinement of model grid?

Review selected water budget components:

- Aquifer storage and recovery programs (direct recharge & pumping)
- Groundwater exports
- High wet-season diversions (refuges?)
- Check crop ET values
- Verify simulated runoff